US Army Corps of Engineers

DCAF Bulletin

Design Construction Analysis Feedback

No. 97-03 **Issuing Office:** CEMP-CE **Issue Date:** 10 Mar 97 **Exp. Date:** 31 DEC 99

CEMP-C

Subject: Vibration of Concrete

Applicability: Guidance

Reference: CEGS 03300, Cast-in-Place Structural Concrete
CWGS 03301, Cast-in-Place Structural Concrete
ACI 309R-87, Guide for Consolidation of Concrete
CRDC 521-81, Standard Test Method for Frequency & Amplitude of Vibrators for Concrete

1. Consolidation is the process of removing entrapped air from freshly mixed concrete, thus causing a more compact arrangement of solids. This is accomplished during concrete placement by either manual or mechanical means. The most effective, and certainly the most widely used consolidation method is vibration, during which the concrete is subjected to rapid impulses which liquefy the mortar, temporarily reducing the friction between aggregate particles and allowing the concrete to settle. When the vibration is stopped, friction is reestablished. Through use of a lower slump concrete, proper vibration should: make placement easier, result in greater density and homogeneity, eliminate rock pockets and entrapped air, improve bond strength with rebar, improve bond between lifts and at construction joints, increase strength and durability, and reduce shrinkage. That so many basic qualities of concrete are dependent on this facet of construction, makes proper vibration absolutely necessary for a quality job.

2. Vibrators come in a variety of types for different types of concrete placement. Some of the more common types are:

a. Immersion or internal vibrators, that are immersed directly in the concrete.
b. Vibrating screeds or pans in contact with the concrete surface, that level as well as vibrate the concrete (Primarily used for slabs and pavements).
c. Form vibrators that are attached directly to the forms.
d. Surface tampers.

3. Immersion vibrators are the most common type for structural concrete. CEGS 03300, Cast-In-Place Structural Concrete requires a minimum frequency of 10,000 rpm. CWGS 03301, Cast-In-Place Structural Concrete specifies a frequency band depending on the

head diameter, amplitude and the configuration of the placement. Both specifications require testing of the vibrator IAW CRDC 521-81. The vibrator speed should be checked frequently, and when it will not operate at the specified speed, it should be repaired or replaced.

4. For effective consolidation, vibration should follow a measured systematic procedure -- not widely spaced random insertions. The vibrator should be inserted vertically 18 to 30 inches apart and slowly withdrawn. In shallow or inaccessible concrete, the vibrator may be used in a sloping or horizontal position. The spacing of the points of insertion should allow some overlapping of the area vibrated so that no area is missed. CEGS 03300 requires 1-1/2 times the radius of action of the vibrator. Vibration periods of five to fifteen seconds for each insertion is usually sufficient. This can be gaged for each spot by the following:

a. Concrete around the stem takes on a glistening appearance.
b. Rise of entrapped air stops.
c. Course aggregate blends into surface but does not completely disappear.
d. The vibrator, after an initial slowdown at penetration, resumes its speed.

5. Overvibration is rarely a problem when the W/C Ratio, as determined by the slump is as low as practicable. Experience has shown that objectionable results are much more likely from undervibration than from overvibration. However, when overvibration does occur the heavier particles of course aggregate settle to the bottom of the placement, and the surface of the concrete appears very wet and consists of a layer of mortar containing almost no coarse aggregate. When this occurs the recommended remedy is to decrease the slump---not the vibration effort.

6. In placements of more than one lift, the entire depth of the new lift should be vibrated, and the vibrator head should travel through the new lift and penetrate several inches into the previous lift to insure an adequate bond between the lifts. Under ordinary job conditions there is little chance of damage from revibration of the previous lift providing the previous lift is still plastic. In a form with a sloping surface, the placement should start at the bottom of the slope, so that the concrete is compacted by the weight of the next lift. If the placement is started at the top, it will separate and flow down the slope when vibrated, and result in unacceptable segregation of the wet concrete (See Encl).

7. Bonding of new concrete to previous placements that have hardened, and have been properly cleaned (greencut) is essentially a matter of thoroughly vibrating the new concrete close to the joint surface.

8. Emersion vibrators should not touch the forms, because they may gouge or otherwise scar the inside face of the forms. This will show as a defect on the surface of the concrete once the forms are stripped. If the rebar is secured firmly in position so that it cannot be displaced, contact with the vibrator will cause no damage.

9. Thin slabs such as sidewalks and floors are best consolidated by use of a surface vibrator such as a vibrating screed. Thicker slabs can be consolidated using immersion type vibrators, or a combination of both immersion type and vibrating screeds.

10. Vibrators should not be used to transport concrete horizontally over long distances within the form. This is a common procedure which is specifically prohibited by both CEGS 03300 and CWGS 03301. This causes unacceptable aggregate segregation. Mixes that can be consolidated by hand probably should not be vibrated, because of the likelihood of segregation. Vibration is used to place drier mixes which yields better quality, greater strength, or more economical concrete.

11. Vibration itself does not improve concrete strength or durability. However, because it permits the use of stiffer mixes (IE: less water), the resulting concrete will have better quality and higher strength. Also, vibration avoids concrete mixes that are too wet that tend to bleed and segregate. This results in harder surfaces, better construction joints, and higher bond strength. The proportion of fine aggregate can also be reduced which in turn allows a lower W/C ratio improving the strength and quality of the concrete.

12. Concrete should be deposited as near final position as possible. It should be distributed in layers, and each layer vibrated. Some hand spading may be necessary in addition to vibration, to insure smooth surfaces, and to remove air bubbles that adhere to the forms. If one follows these procedures, it is not difficult to consolidate low slump concrete.

13. This DCAF has been coordinated with the following HQUSACE organizations: Engineering Division(CEMP-ET); Operations, Construction and Readiness Division(CECW-OC); Engineering Division(CECW-EG). POC for this DCAF is C. J. Harris, CEMP-CE. Telephone: (202) 761-8801.

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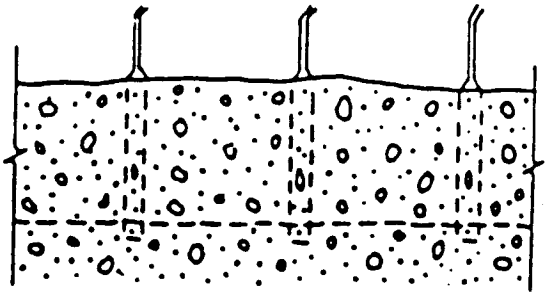
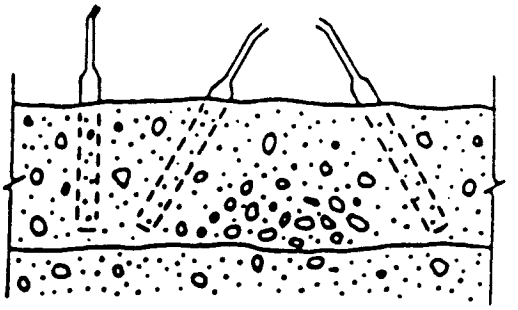


CORRECT

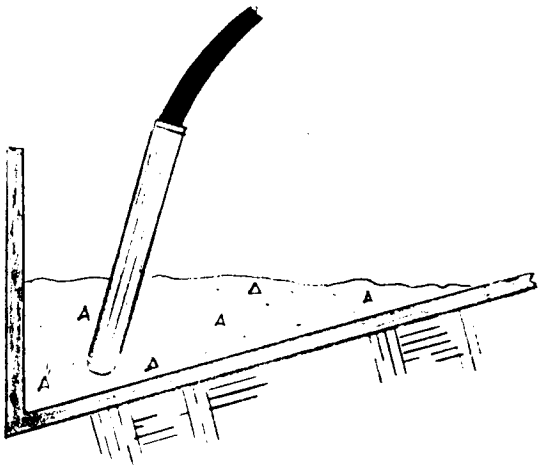
VERTICAL PENETRATION OF VIBRATOR A FEW INCHES INTO PREVIOUS LIFT (WHICH SHOULD NOT YET BE RIGID) AT SYSTEMATIC REGULAR INTERVALS FOUND TO GIVE ADEQUATE CONSOLIDATION.



INCORRECT

HAPHAZARD RANDOM PENETRATION OF THE VIBRATOR AT ALL ANGLES AND SPACINGS WITHOUT SUFFICIENT DEPTH TO ASSURE MONOLITHIC COMBINATION OF THE TWO LAYERS.

SYSTEMATIC VIBRATION OF EACH NEW LIFT



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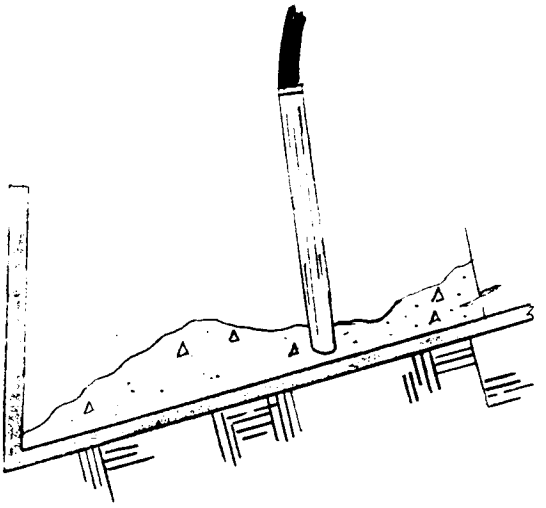

INCORRECT

START AT THE BOTTOM OF THE SLOPE WHEN PLACING CONCRETE ON A SLOPING SURFACE. THE WEIGHT OF THE NEXT LIFT WILL INCREASE THE COMPACTION. IF THE CONCRETE IS PLACED AT THE TOP OF THE SLOPE, IT PULLS APART AND FLOWS DOWN THE SLOPE WHEN VIBRATED.

PLACING CONCRETE ON A SLOPE

ENCL